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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : H02P 3/14 — A1

(11) International Publication Number: WO 92/05626

(43) International Publication Date: 2 April 1992 (02.04.92)

(21) International Application Number: PCT/SE91/00627

(22) International Filing Date: 18 September 1991 (18.09.91)

(30) Priority data:
9002970-3 18 September 1990 (18.09.90) SE

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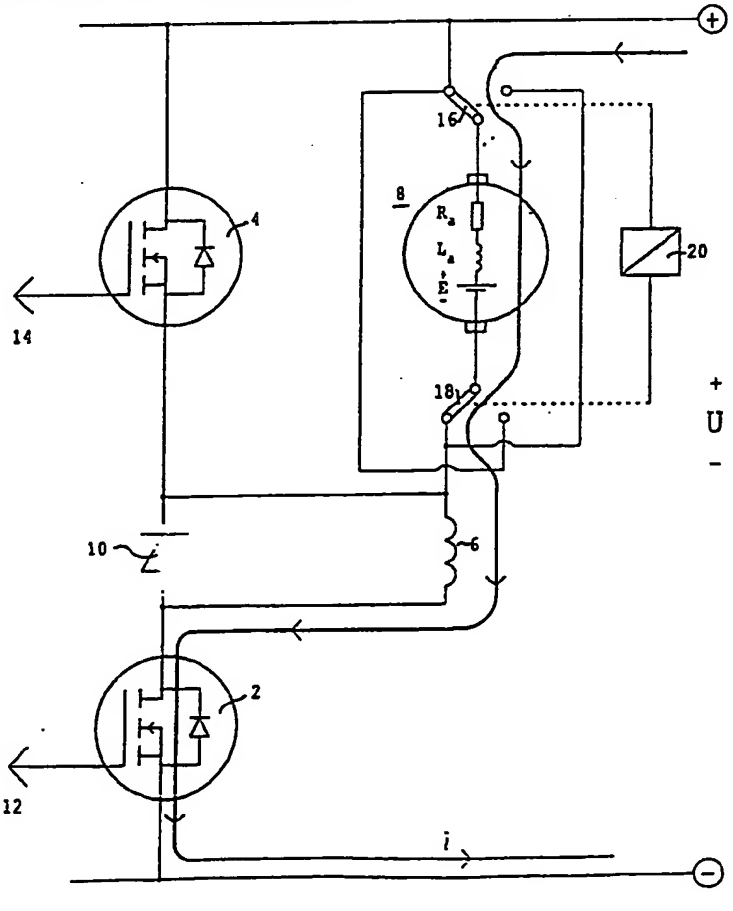
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.
In English translation (filed in Swedish).

(54) Title: APPARATUS FOR CONTROLLING SERIES WOUND D.C. MACHINES

(57) Abstract

An apparatus for controlling a series wound DC machines comprises an element (10) with a diode function connected in parallel with the field winding (6), a first switching element (2) connected between the field winding and one pole of the supplying DC source (U), as well as a second switching element (4) connected in parallel with the armature (8), the two switching elements being mutually connected via the element with a diode function.



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Apparatus for controlling series wound D.C. machines

The present invention relates to an apparatus for controlling series wound DC machines with the possibility of maintaining different currents in field and armature windings, more specifically to such a machine having an element with a diode function connected in parallel with the field winding and a first switching element connected between the field winding and one pole of the supplying DC source.

Different forms of rotation speed control and the regulation of DC machines using a chopper are already known, see e.g. EP 0 054 614 and GB 1 422 965. The basic concept is that by controlling the pulse ratio of the chopper the mean value of the output voltage can be controlled, thus regulating the D.C. machine.

Single, double and quadruple choppers are envisaged, depending on the number of quadrants in which the chopper operates. This may be seen from Figs 1 and 2, Fig 1 illustrating the operational cases for the different quadrants in the current-EMF plane for a DC machine, and fig 2 is a diagram of the machine defining the positive reference directions of current i and electromotive force E.

With a single quadrant chopper, for example, a DC machine may be driven forward but not braked. With a double quadrant chopper, a DC machine may also be electrically braked by feeding the mechanical kinetic energy stored in motor and load back to a driving energy source i.e. the motor goes over to operation as a generator. Such regenerative braking of separately magnetised DC motors is previously known and often used in different applications, e.g. SE 385 360, US 3 984 743 and DE 3 717 279.

Common to all previously known solutions for regulating DC machines with choppers, while enabling regenerative braking of the machine, is that they are complicated and

require a relatively large number of components.

The object of the present invention is to provide a new apparatus for controlling series wound DC machines for double quadrant motor/generator operation with feed back of energy for braking without mechanical switching of the armature or series field winding, which apparatus is much simpler than constructions already known and requires a minimum of components.

This object is attained with an apparatus of the kind mentioned in the introduction and having the characterizing features disclosed in claim 1.

With the device in accordance with the invention there is thus achieved electrical braking of the machine with feed back of energy to the supply source without mechanical switching with the aid of contactors or the like, and with a considerably simpler, and consequently cheaper, circuit than has been known earlier. A still further advantage with the apparatus according to the invention is that a current can be maintained through the field winding without any mean current passing through the armature, this operational case being utilisable for preventing the motor running away. In this way e.g. impermissible high speeds in vehicle operation can be avoided, without an extra shunt winding needing to be arranged.

By suitable controlling the switching element shall conduct/block current in the positive direction, and at least conduct current in the negative direction. In accordance with a further advantageous development of the apparatus according to the invention, the switching elements are field effect transistors (FET's). However, a plurality of other kinds of components may be used as switching elements.

In accordance with a still further advantageous embodiment of the apparatus according to the inventon, it is also utilisable for quadruple quadrant operation, by having a pole reversing contactor arranged in the armature or field circuit, which contactor has the sole task of reversing the rotational direction of the machine.

An embodiment of the apparatus according to the invention, with switching elements in the form of FET's,

and selected as an example, will now be described in more detail, with reference to figs 3-8 on the accompanying drawings, on which Fig 1 illustrates the diffent operational types in the current-EMF plane for a series wound DC machine, Fig 2 illustrates the positive reference directions for current and EMF in the PC machine, and Figs 3-8 illustrate an embodiment of the apparatus according to the invention in different operational modes.

A series wound DC machine, including armature 8 and series field windings 6, is connected to a supplying DC source U, e.g. a battery U. The armature is electrically represented by a series connection of a resistor R_a an inductance L_a and an EMF E, counterdirected in relation to the battery voltage U.

Between the field winding 6 and the minus pole of the battery U there is connected a switching element in the form of a FET 2. Via a diode 10, connected in parallel with the field winding 6, the FET 2 is connected in series with a second switching element 4, also in the form of a FET and connected in parallel with the armature.

The FET's 2,4 are connected via their controls 12 and 14 to a suitable control unit, which is not more closely described.

A pole reversing contactor is schematically shown at 16,18 and 20, and is arranged in the armature circuit to enable reversing of the revolutional direction of the machine, and thus so-called quadruple quadrant operation. This pole reversing contactor may alternatively be arranged in the field circuit.

In Fig 3 there is illustrated a first motor operation case representing switching on the machine. Here, only the FET 2 is ON for closing the current circuit, as shown in the Fig. In this case the current i increases as long as the battery voltage U exceeds the EMF E plus the resistive voltage drop across armature and field.

In Fig 4 there is illustrated a second motor operation case with freewheeling armature and field currents i_a and i_f respectively. In this case the transistor 2 is OFF, the inductances of armature 8 and field winding 6 continuing to

drive the freewheeling currents i_a and i_f respectively, as shown in the Fig.

In Fig 5 there is illustrated a special motor operation case, enabling the increase of the field current i_f in relation to the armature current i_a. In this case, both transistors are ON, and the entire battery voltage is across the field winding 6, resulting in an increase of the field current i_f. If the current through the transistor is denoted by Δi_f, there is thus obtained

$$i_f - i_a + \Delta i_f$$

In this case, when the armature 8 is short-circuited by the transistor 4, the armature current i_a , will decrease, and since a current i_f through the field winding 6 is maintained in this case, without any mean current i_a needing to pass through the armature, i.e. when $i_a = 0$, then $i_f = \Delta i_f$, the series motor can be prevented from running away in this case. An important field of application here is to prevent impermissibly high speeds in vehicle operation without needing to arrange special shunt windings.

In Fig 6 there is illustrated the introductory phase in a case of generator operation. In this case, both the transistors 2, 4 are ON, as in the case illustrated in Fig 5, and the entire battery voltage U will be situated across the field winding 6, thus maintaining magnetisation of the machine. The EMF E in the armature 8 simultaneously drives a current i_a through it in the opposite direction to the one in the case of operation as a motor. This operation mode continues until the field current i_f has increased to a predetermined magnitude and then the transistor 2 is switched to OFF, according to the operation case shown in Fig 7.

In Fig 7 the case is thus that the transistor 2 is OFF, while the transistor 4 is ON. The armature current i_a which is driven by the EMF E of the machine, increases, while the field current i_f freewheels, as illutrated in the figure. This operation case continues until a suitably large armature current i_a is attained, i.e. suitable braking effect is obtained.

Finally in the operation case illustrated in Fig 8, the

transistor 4 has just switched to OFF, the inductance L_a in the armature 8 then continuing to drive the current i_a, which is fed back to the driving battery U. The field current i_f freewheels, as shown. In this case the series machine thus operates as a generator and feeds back energy to the battery U.

When braking the machine, the generator operation cases according to Figs 6-8 are repeated several times.

Claims

1. Apparatus for controlling a series wound DC machine and having an element with a diode function connected in parallel with the field winding and a first switching element connected between the field winding and one pole of the supplying DC source, characterised in that a second switching element is connected in parallel with the armature of the machine, the two switching elements being mutually connected via the element having a diode function.

2. Apparatus as claimed in claim 1, characterised in that the element with a diode function is also a switching element.

3. Apparatus as claimed in claim 1, characterised in that the element with a diode function is a diode.

4. Apparatus as claimed in claim 1 or 2, characterised in that the switching elements are field effect transistors.

5. Apparatus as claimed in any one of claims 1-4, characterised in that a pole reversing contactor is arranged in the armature or the field circuit.

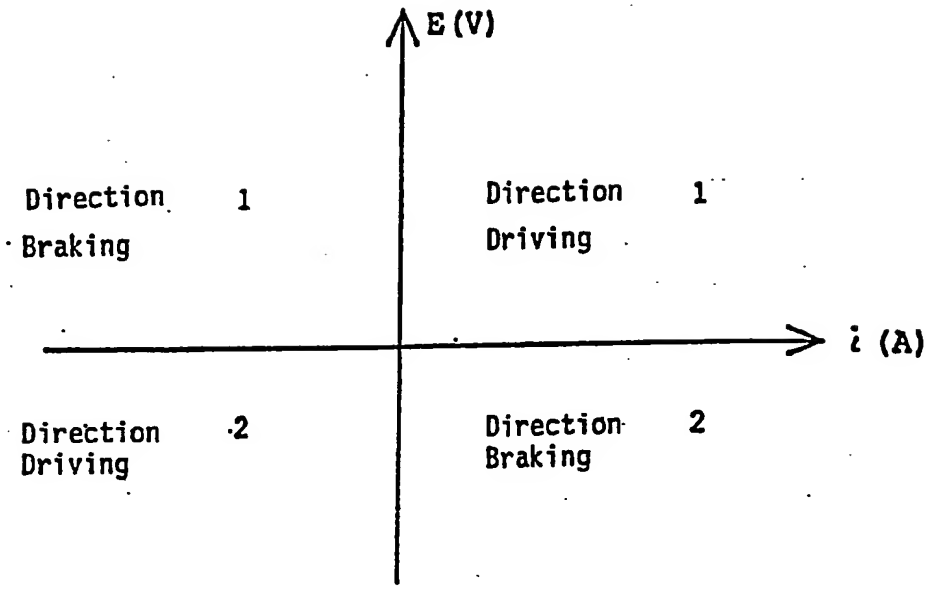

Fig. 1

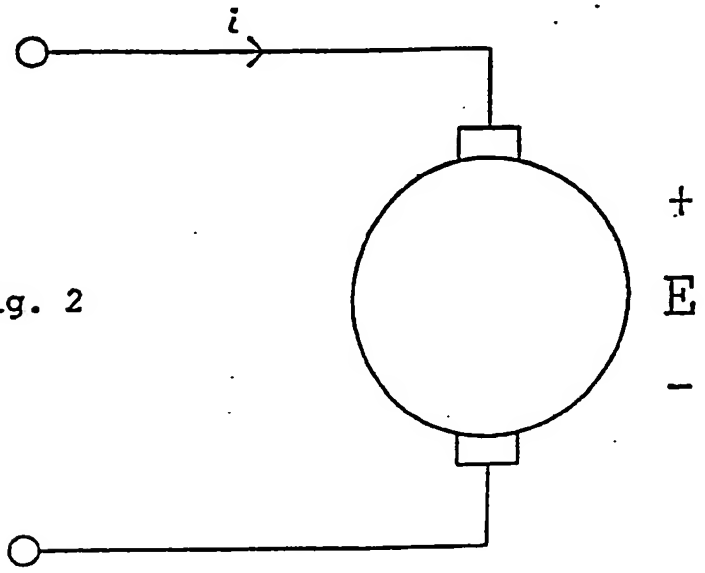

Fig. 2

Positive reference directions of the DC machine

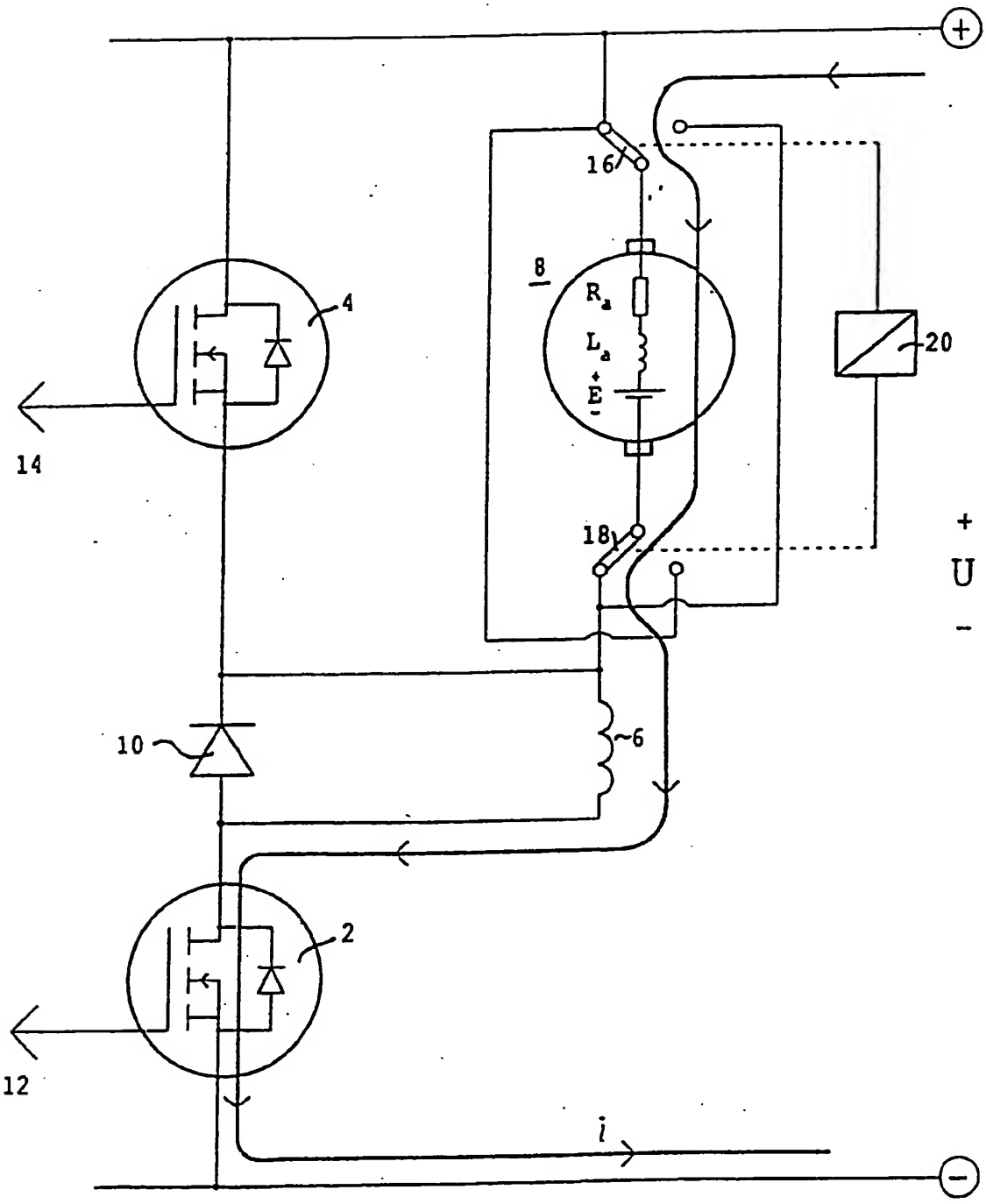

Fig. 3

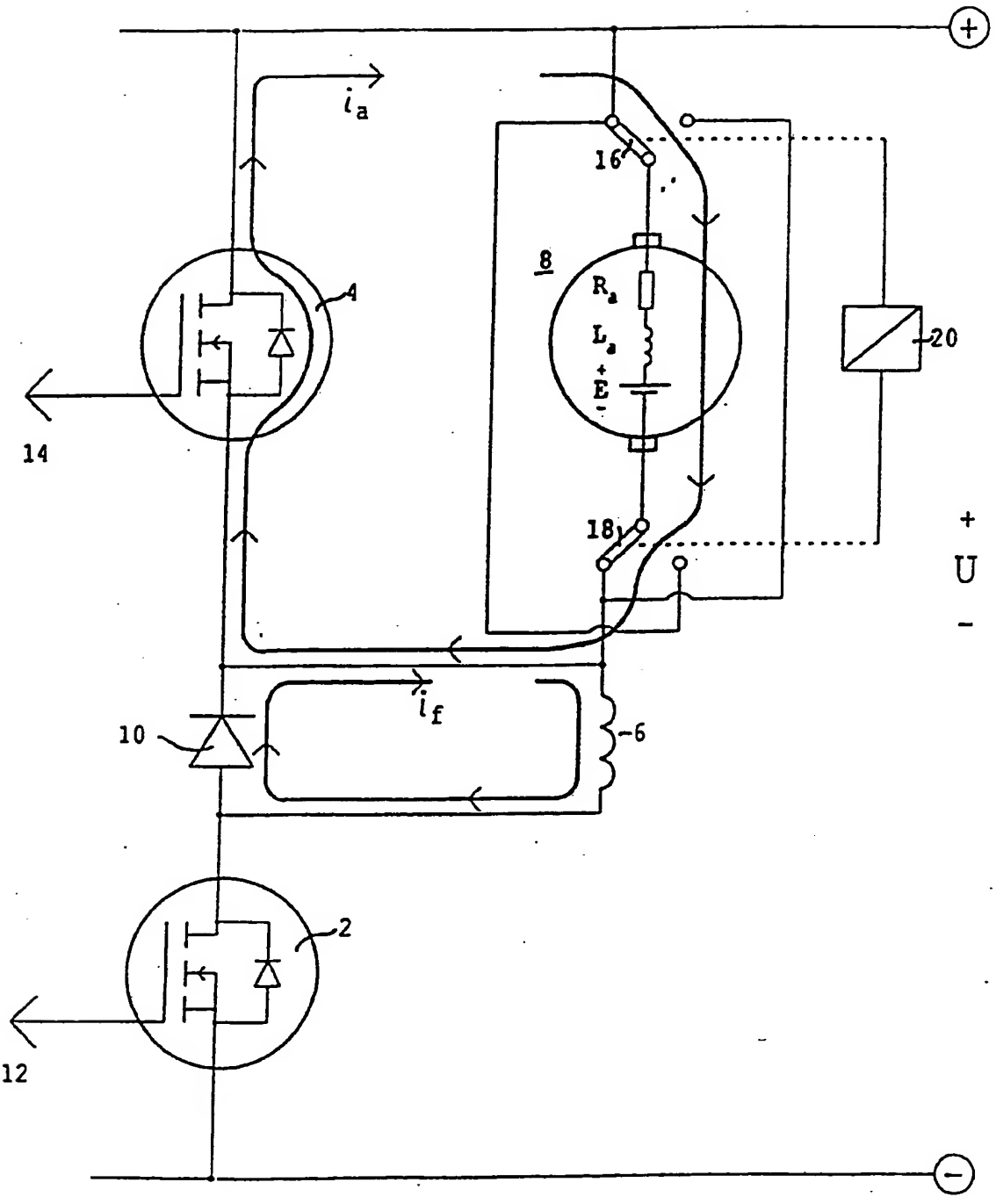

Fig. 4

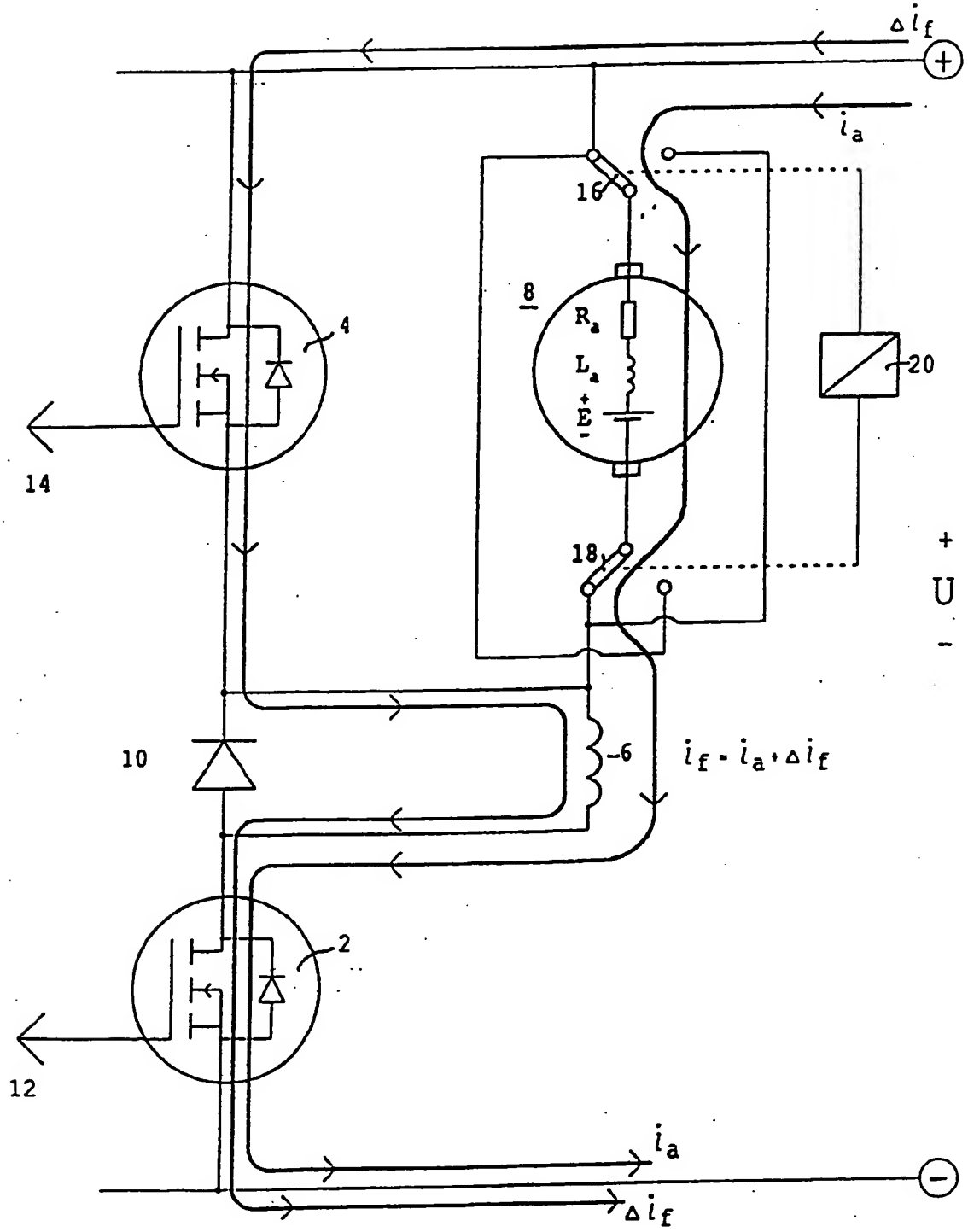

Fig. 5

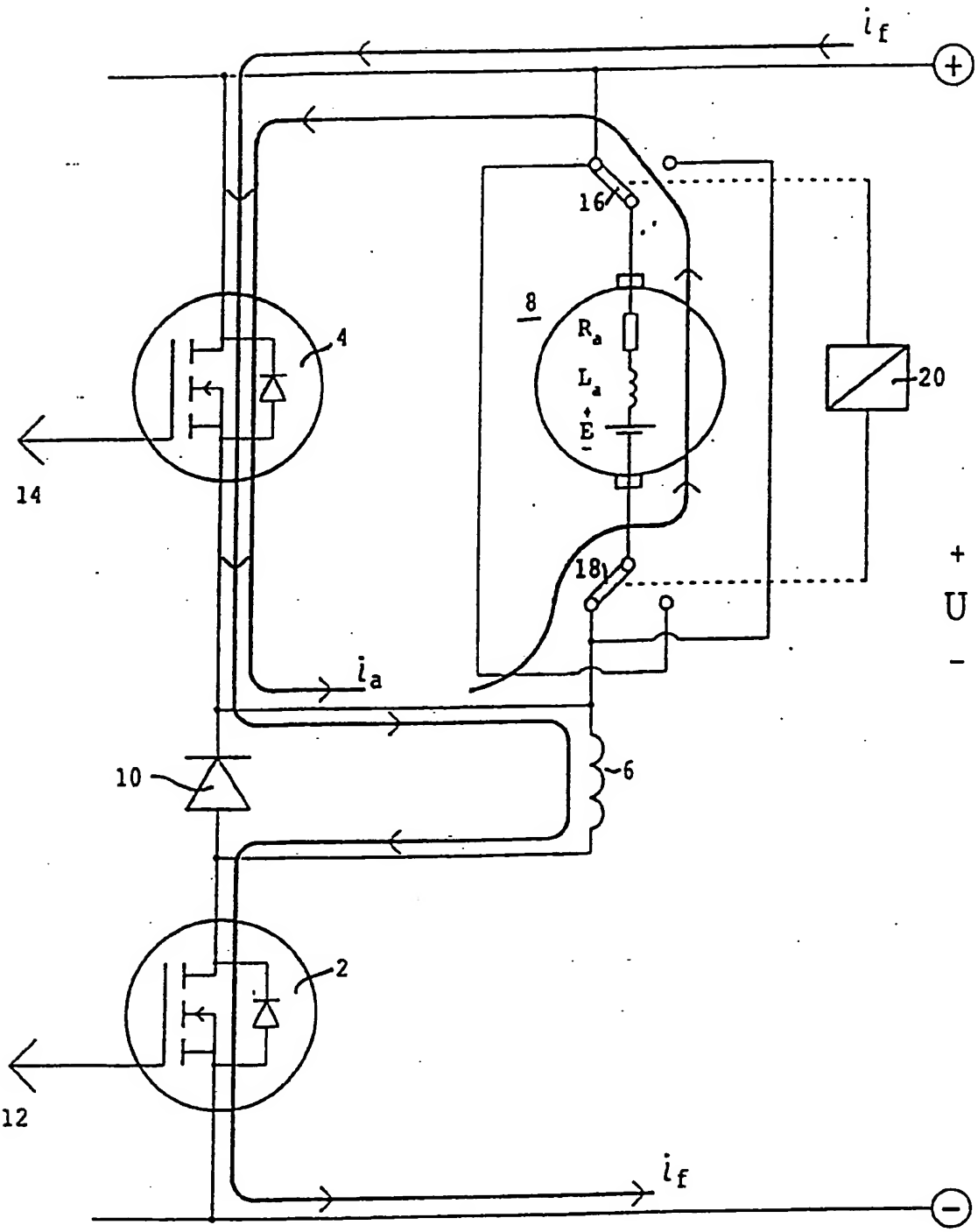

Fig. 6

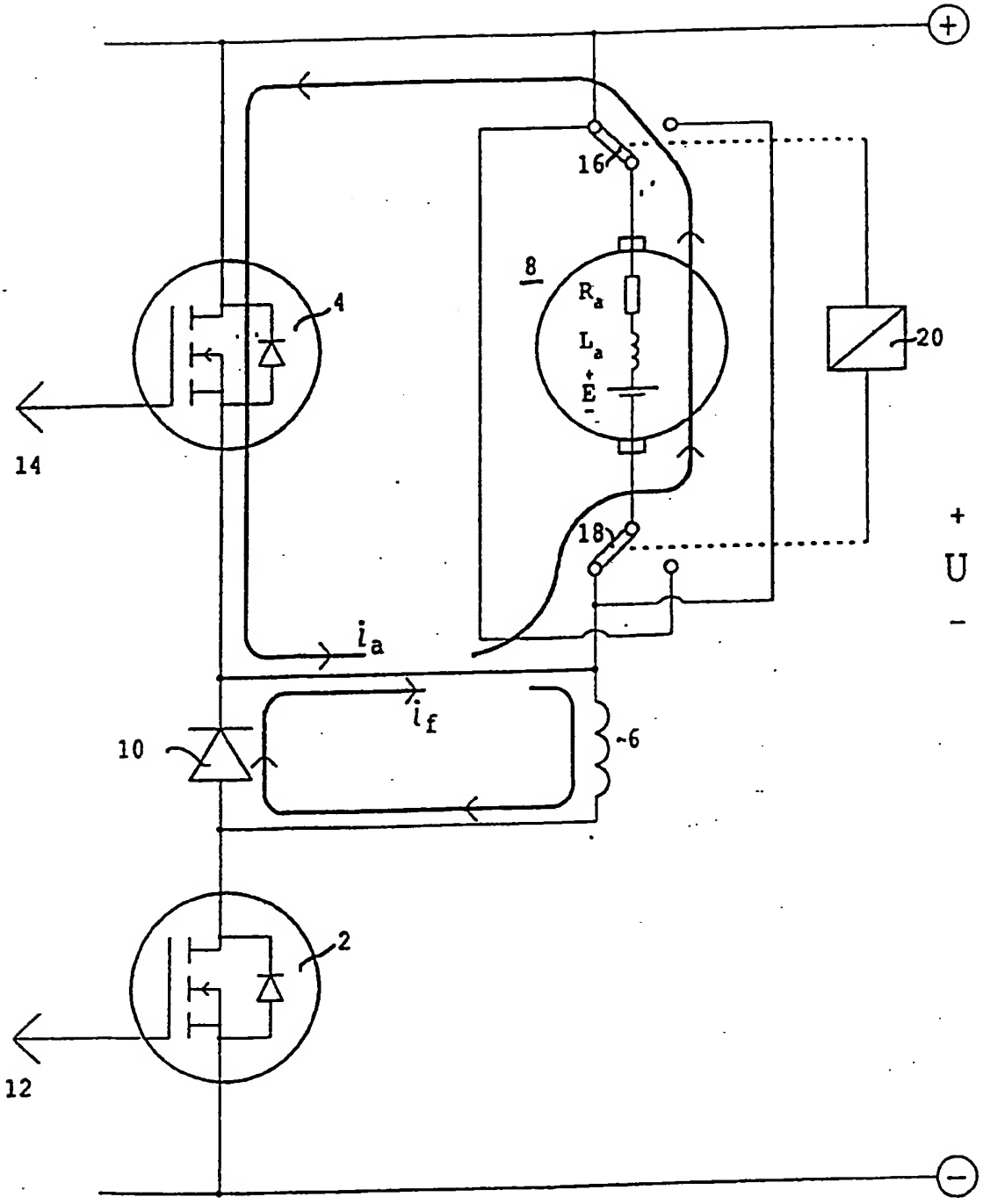

Fig. 7

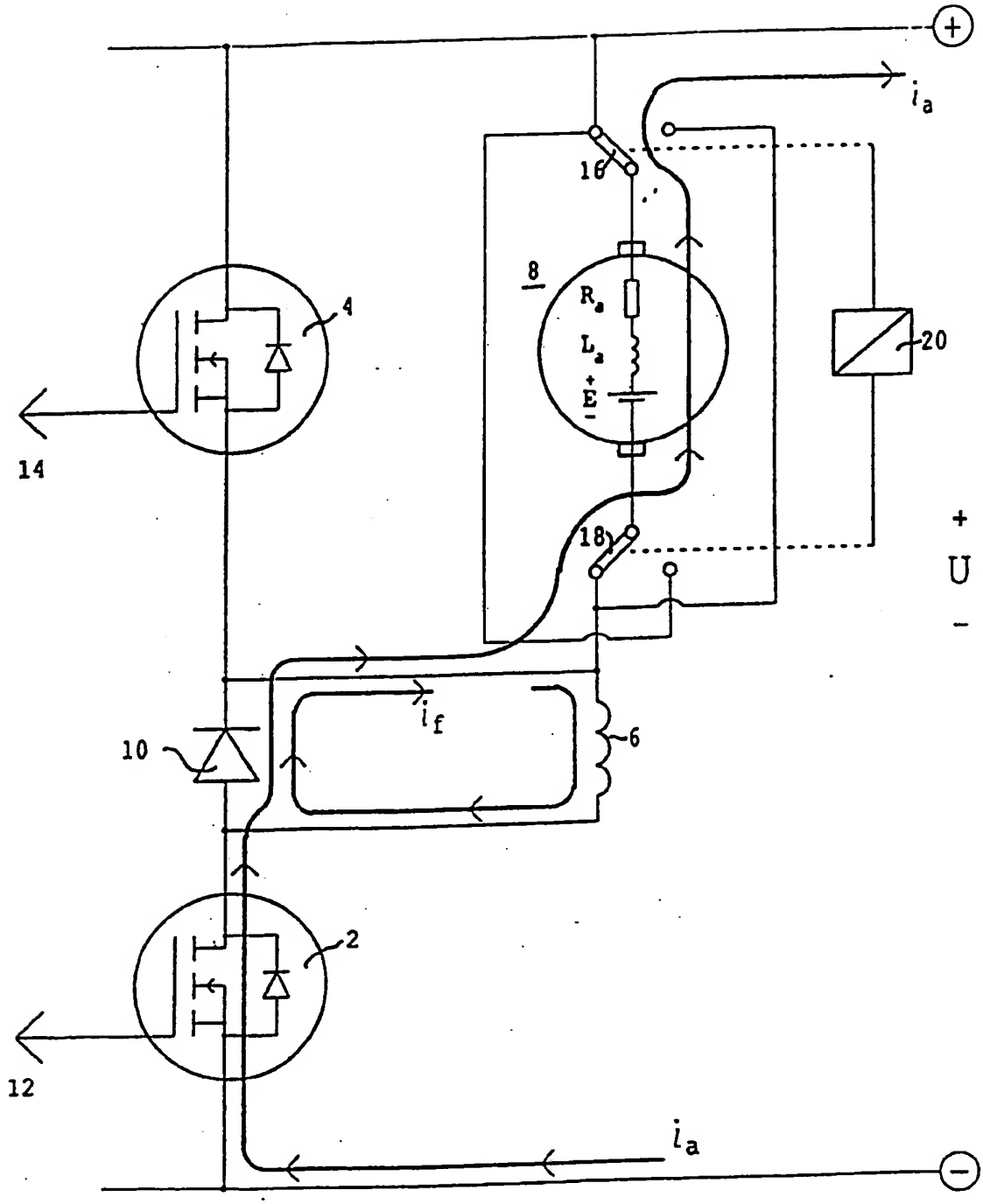

Fig. 8

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 91/00627

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: H 02 P 3/14

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	H 02 P, B 60 L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	EP, A1, 0054614 (ROBERT BOSCH GMBH) 30 June 1982, see the whole document --	1-5

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
4th December 1991	1991-12-11
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/SE 91/00627

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 31/10/91
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A1- 0054614	82-06-30	DE-A-	3048999	82-07-15
		JP-C-	1588502	90-11-19
		JP-B-	2013553	90-04-04
		JP-A-	57126289	82-08-05
		US-A-	4422021	83-12-20